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THE RECENT TEA DEVELOPMENTS IN GEORGIA

BY

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In the year 1914 Dr. G. D. Hope wrote a most interesting and informing article in the Quarterly Journal of the Scientific Department of the Indian Tea Association giving an account of his visit to the tea districts of Georgia in the Trans-Caucasian provinces of Russia. He described the conditions under which tea was then grown in this region and indicated the extent of the industry at that time. However, the interest in the matter at that time was limited for there was no prospect of the rapid extension of tea cultivation in this part of the world, and, beyond the small area of tea grown by the peasants and a few small private owners, the whole of the Georgian tea was in the hands of the Czar himself and one or two rich Russian merchants. The whole area under tea amounted to about 2,000 acres or a little less, and this tea, except such as was in the hands of the peasants who planted it for their own use, was worked by Chinese methods and Chinese men who were responsible for the gardens and for the manufacture of tea.

At the Revolution the tea passed into the hands of the State, but for several years this made little difference in the method of working, and practically no extension of the tea planting in Georgia occurred. But about 1926 a scheme was launched for the increase of the area under tea, and investigations were begun to find out the amount of land with a suitable climate which could be made available for growing tea in Trans-Caucasia. All investigations led to the conclusion that the successful growth of tea

would probably be limited to Western Georgia, but that within this area there was enough available land for a very large extension of the industry. Since then, progress has been rapid. The new tea planted in 1926 amounted to under 70 acres but in 1927 nearly 1,500 acres were planted and over 5,000 acres in 1928. At present the land under tea in Western Georgia amounts to about 55,000 acres and the present intention is that, within about three years, this area will be multiplied between about two to three times. Such an area, as will be seen, will be a substantial factor in the future supply of the tea world, though, with the increase of prosperity in Russia, it is estimated that that country alone will much more than absorb all the tea that Georgia can produce, without affecting her present imports from the other tea producing countries of the world.

But in view of the present circumstances it may be worth while to review the conditions under which tea is produced in Georgia in a slightly more detailed manner than was done by Dr. Hope in 1914 when tea planting was little more than a hobby of an emperor and certain rich merchants.

The tea area of Western Georgia lies in a triangular area of land at the extreme east of the Black Sea. This is enclosed on the north by the Caucasus Mountains, on the south by the Armenian Mountains, and on the east by the ridge which joins these two mountain ranges. It is open on the west. Under these circumstances it receives a rainfall greater than in almost any other part of the Soviet Union. The rainfall is fairly well distributed throughout the year. This area is also protected from the winter cold which prevails in practically all other parts of Russia, and thus, though the winter temperature is lower than we are accustomed to associate with tea cultivation, yet the area is entitled to class itself as sub-tropical.

Coming to details, the actual rainfall varies from 100 inches near Batoum to about 50 inches in the northern part of Western Georgia. The distribution of this rainfall at Chakwa, which was

the first tea centre, is shown in the following average figures for each month of the year.

	Inches
January	10.00
February	6.80
March	5.76
April	5.76
May	4.56
June	7.44
July	7.12
August	9.28
September	10.68
October	12.12
November	10.68
December	9.76
Total ...	99.96

The main difference between this rainfall and that of the best Indian tea districts lies in the fact that so much of the rain falls in the cold weather. Much of this rain, in fact, falls as snow and it is quite interesting to see photographs of the tea almost covered with a thick layer of snow.

The rainfall just, given, however, represents the best conditions of the area. In the northern and eastern portions, the total rainfall is much lower and in some cases, where tea has been planted, it does not much exceed 50 inches per annum. Moreover, the distribution is not so good as that found at Chakwa, and there is liable to be drought in April and May, when the tea should be growing as vigorously as possible. The total quantity and the distribution of the rainfall limits to a very marked extent the actual area which is fit for tea planting, and most of the centres for which details of rainfall were given by Dr. Hope in 1914 are now recognised as being quite unsuitable for tea. But even if these centres are left out, there still remains a very large portion of Western Georgia in which the rainfall at least is fairly satisfactory for tea.

On the other hand, in no part of Western Georgia are the temperature conditions really satisfactory, and, even at the most favourable points, the months from November to March are much colder than is desirable for tea cultivation. Even near Batoum, which represents the mildest climate in the country, the minimum temperature during these months may go as low as 22°F (−5.7°C). It is true that this low temperature does not occur every year, but in most seasons it goes low enough to damage seriously the higher *jats* of tea. I have myself seen young tea shoots nipped off by frost in the early part of December in this very region. In the remainder of the area, the conditions are liable to be even more severe, and there are records of temperatures as low as 10°F (−12°C). Of course, such temperatures are very occasional, and the normal minimum winter temperature is much higher than this, but the possibility of the occurrence of such low temperatures will always make tea planting difficult and will prevent the use of the more delicate types of tea. The coldest month is February, and, as will be quite clear, this has an important bearing on the way in which the winter work of the tea garden can be carried out and on the date at which plucking can commence in the following season.

The extent of the long cold weather, which I have tried to describe, will tend, of course, to reduce the length of the plucking season, and, hence, the quantity of tea which can be obtained per acre. On the other hand, the climate during June, July, August and September is very suitable for the vigorous growth of tea, and there seems to be no reason why during the height of the season very strong and vigorous flushes of leaf should not be obtained.

Turning to the question of the soils of Western Georgia, it may at once be stated that hitherto practically all of the tea that has been planted has been put out on low hills and plateau lying at the foot of the great mountains to the north and south of Western Georgia. Between these and the Black Sea there lies a region of flat clay land and swamp very little above the flood level of the rivers. Most of these lands, even when drained, do not seem likely to be suitable for tea and under the present arrangements in Russia

they are likely to be utilised for other commercial crops. On the low hills and plateau to which I have referred, there has been only a limited amount of cultivation hitherto, though in suitable places, grapes and certain of the hardier types of oranges (tangerines chiefly) have been cultivated extensively and will be cultivated more in the future. The main food crop of the people is maize, which is grown both on the low flat land to which I have referred and on the plateau and hill land which is suitable for tea.

The soil of these low hills and plateau lands varies a good deal, but most of them consist of a red soil with a somewhat heavier and yellower sub-soil. At intervals among this type of soil and sub-soil one comes across a sandier surface soil with gravel underneath. In fact a very large part of the area reminds me very much of a good deal of the *teela* and plateau land of Cachar and will probably have all the difficulties which have been found on such land in India. The soils of the original tea area near Batoum, Chakwa and Osurgetti have been very carefully and thoroughly studied by Professor Zakharoff, and I doubt whether a more thorough study of soils in any particular place has ever been made in any part of the world. His studies show that all these soils contain very little lime—as indeed is necessarily the case if tea is to flourish. The acidity of the soil varies of course, but is usually represented by a pH value of 5.0 to 5.5.

Similar soils are found in other parts of the region, though the impression I got was that on the whole in the northern and eastern parts of the area the soils are poorer and less suitable, while there are apt to be patches of land which seems to be spoilt for the purposes of tea by the presence of a substantial amount of calcium carbonate.

The general impression which I get of the soils of Western Georgia as compared with those of north-east India is that on the whole they are poorer than most of those usually planted in the Indian tea districts. However, while it is usual in India for the sub-soil to be fairly light (though of course examples of heavy soils occur even on plateau land), in Georgia the sub-soil usually appears to be heavier than the surface soil. This at once intro-

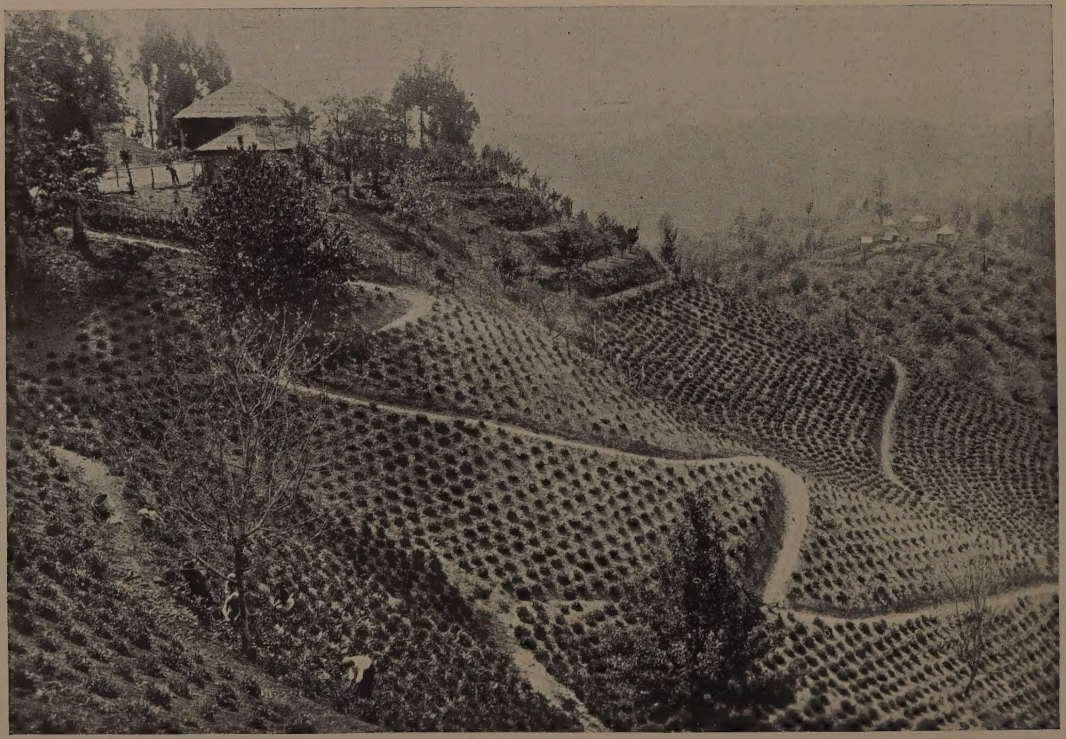
duces difficulties with regard to the drainage and with regard to the securing of deep root development for the tea plant.

At this point I may say that the analysis of soil from Chakwa given by Dr. Hope in 1914 does not represent the ordinary common type of tea soil in Georgia. It shows far more lime than is usually found and moreover suggests more clayey soil than is generally utilised. On the other hand the amount of organic matter shown by Dr. Hope is much higher than is generally found in almost any part of the Georgian tea area.

The original tea which was planted in Georgia consists of hybrids obtained from various sources, China, Japan, India and Ceylon. Originally high *jat* seed was obtained from Assam but the plants from this source were found to be unable to resist the winter cold and were gradually abandoned. In fact, of the old tea now growing in Georgia, the best *jat* that I found was from seed said to have originated from Ceylon. It was very mixed, but among the plants were some which were decidedly good *jat*.

With the new development since 1926 there have been renewed efforts to find out whether any of the better *jats* of tea can be utilised in Georgia. So far results indicate that the suitability of the genuine Assam Indigenous or Manipuri types is limited, and it is pretty certain that they will only be useful for commercial tea in a very small portion of the area. For the rest, the land has been planted with hybrid and China tea derived in part from India (chiefly from the Darjeeling district), from Japan, and to a less extent from Ceylon, while a large part of the new area has been put out with seed derived from the old bushes already growing in Georgia itself.

It is, of course, a very serious handicap to tea cultivation in Georgia that the really high types of tea cannot stand the climate there, but the handicap is greater than appears at first sight, because, while high *jat* tea seed can be obtained so as to give fairly uniform plants, it seems at present impossible to get hybrid or low *jat* tea seed which give plants of uniform productive power, for the seeds are usually collected in India, Ceylon, Japan, or even



Old tea near Batum.

in Georgia itself, from a mixed lot of plants which are themselves of very unequal productive power. Hence it will be seen that it is of prime importance that the young plants should be carefully selected so as to reject those which give little leaf and a large quantity of flower and seed. It is in fact, a great desideratum that a method should be devised whereby the productive power of any plant can be judged with some approach to accuracy from the condition of the plants at an early stage. Such methods do not appear to be worked out for seedlings in any tea growing country, but it is one of the matters to which considerable attention is being given in connection with the new tea area in Georgia.

Most of the land so far planted during the last three or four years has been put out "seed-at-stake", and the tendency is for "hedge-planting" to be adopted, for reasons which will shortly appear. The distance between the rows is usually 5½ feet (1.75 metres). In future, nurseries will be used to a very much greater extent than has been done hitherto though it is intended to carry on "seed-at-stake" planting on a very considerable part of the area. During the last and the present seasons, under this latter method, large numbers of seed are planted in the row, a method which allows the removal of a considerable portion of undesirable plants later on, while still leaving enough to form a satisfactory hedge of plants. Planting is usually done between January and June. The seed put out in the later months that is to say in April, May and June, even in the climate of Georgia, is likely to be burnt off by the sun just above the ground and so give unsatisfactory plants later on. Undoubtedly, the best time for planting tea seed in Georgia is in the first three months of the year.

The growth of plants under Georgian conditions is, of course, slower than is customary on the plains of India, but it does not differ widely from that on well prepared land in the Darjeeling district. The critical time with the plants, however, seems to be the first cold weather, and at this time a certain proportion of the plants from every class of seed hitherto used have been killed. The difference between the resisting power of seed from various

sources is very remarkable and from the results and tests made the choice of sources of seed in the future will be determined. In view of the heavy sub-soil which is usual in Georgia, it has proved to be of great importance to loosen the sub-soil into which the roots penetrate and the difference between the growth of plants where this is done and where it has been omitted is very remarkable indeed.

One of the features which will strike an observer from India is the extent to which mechanical methods are adopted in connection with all possible operations in tea culture. Thus, for instance, wherever the slope of the land allows, the soil is prepared for planting by the use of heavy tractors, ploughs and sub-soilers. Further, almost all inter-cultivation of the tea after planting is done by machines, and after much experimenting the actual machine used for this purpose is a small petrol motor cultivator made by Siemens-Schuchert of Germany. The inter-cultivation done by this machine is very satisfactory, so far as I can judge, and it enables about two and half acres to be cultivated in a day of eight hours, using one and three quarter gallons of petrol. This machine, of course, does not actually keep the soil loose in the rows themselves and this must be done by hand, but over about 75% of the land it certainly seems to do very well and very much better than all the attempts I have seen at cultivation of tea by animal power.

A very considerable portion of the tea already planted lies on slopes which tend to erode badly, just as has been the case of the steep slopes of both India and Ceylon, and as a result it is quite clear that the prevention of such erosion is one of the biggest problems which face those who are now responsible for tea cultivation in Georgia. Careful terracing was adopted in parts of the early planted tea gardens, but a method for dealing with the heavy slopes which has now been decided upon is that of planting in contour trenches about eighteen inches deep which are made by hand and then filled in as far as possible with surface soil. In addition to this, cross drains are put in on all but the slightest slopes, as the heavy sub-soils render such drains dug down to a

Land terraced ready for planting tea.

depth of three feet almost a necessity for the production of healthy tea.

From what I have seen during the past two years I think it may be taken that the tea in Georgia will begin to yield in the fourth year after planting, and I should, say, on the whole, that the plants are likely to be nearly a year later in reaching their full growth of yielding power than is customary in the plains of India. Plucking has hitherto been done on a system which has been tried and rejected in the more advanced tea growing countries. The actual number of pluckings has been small, as is still customary in China and Japan, with the result that the bushes have largely "run away" in the middle of the season, and so closed up before the end of September. This, of course, has been partly caused by the lack of a sufficient amount of labour for plucking,—a lack which will be difficult to supply in the future and which forms perhaps the biggest obstacle to Georgian tea cultivation.

This leads me to what is perhaps the most interesting development of mechanization which has been attempted in connection with Georgian tea culture. Mechanical plucking has been usually looked upon in the East Indies as an impossibility, and everyone, both there and elsewhere, recognised that no mechanical method of plucking can be imagined which does not cause much bad, torn and broken leaf to be plucked, but all the same the Japanese have used for many years a system of plucking by shears which is said to increase six-fold the plucking capacity of each worker. These Japanese shears are now in general use on the estates in Georgia, though, on the smaller plots hand plucking is still carried on. The workers in Georgia have, however, gone one stage better than the Japanese shear, and now at least two machines have been devised which will pluck the leaf far more regularly and at a still more rapid rate. Of course, the use of these or any other mechanical method of plucking will require that the bushes are definitely shaped to suit the method, and that the plucking shall be more frequent than has been usual in Georgia in the past. In spite of everything, at the best, there will be a very large amount of broken leaf, and it is recognised as neces-

sary that the leaf going into the factories shall be sorted out so as to separate, as far as possible, the cut leaves and tips from the properly plucked shoots. This matter is, in hand, and one pneumatic method of such separation has already been devised and is in use at the Chakwa factory.

Only one third of the tea area which will ultimately be planted in Georgia will be in the form of estates such as we know them in the East Indies. Even at present, a very large proportion of the tea area is cultivated by peasants who either make the tea themselves by hand methods or, as is now more frequently the case, send it to one of the small factories which are being dotted about the tea areas, and extension of this peasant tea, in the form of collective holdings (*"Kolkhoz"*), is one of the most interesting developments at the present moment. The importance which is attached to it may be judged by the fact that out of fifteen factories now in existence in Georgia, about ten are devoted to the manufacture of tea so produced.

This leads me to the question of factories, and I may say at once that those which have been erected during recent years are of very good design and are equipped with the latest machinery. The factory at Chakwa, in the original home of tea in Georgia, is a very large one even according to Indian standards. In this, as elsewhere, the latest methods of the East Indies have been copied and most of the machinery is of a similar type to that used in the most up-to-date plantations in the East. Under the conditions in Georgia it is clear that withering of the leaf must be of a more or less controlled type, and withering in lofts with fans is therefore, usual.

Though all the mechanical devices customary in the East have been adopted in the factories, yet the Russian workers are not by any means satisfied with the amount of mechanization hitherto attained. In fact, as in other industries in Russia, there is at present a passion for mechanization, in order that labour may be saved, and I should not wonder that within a year or two the the Georgian authorities may be able to reach a degree of mechanization which has not been attained elsewhere in the world.

Plucking.

Chakwa Factory
Ferro-concrete, completed in 1930.

The tea produced hitherto has been of a very ordinary type. A recent London Market opinion on these teas read as follows :—

> "All are clean sweet liquoring teas of a non-descript neutral character with no trace of commonness or burn. They evidence careful manufacture and grading, and indeed are a most interesting lot. It remains to be seen whether from the climate and soil of Georgia it will be possible to produce any characteristic flavour."

The lack of quality in Georgian teas indicated by this opinion may probably be partly due to the essential conditions of tea growing in Georgia but it is also largely a result of the methods of pruning, and partly of plucking systems. It is likely that the general crop of tea will improve though at present I cannot picture the production of a really good and flavoury tea in the country.

As would be expected from what has been already written, the yield of tea per acre in Georgia is likely to be considerably below what we are accustomed to get in the plains of India. If, however, we compare the yield in Georgia with that which it is customary to obtain in the higher estates of the Darjeeling district, it will be found that the old tea in Georgia is now yielding at least as highly as most of these gardens. In 1930 the old tea in Chakwa was giving about 350 pounds of made tea per acre. With the adoption of better methods and the use of considerable quantities of manure this yield was raised in 1931 to between 400 and 500 pounds of made tea per acre. As far as one can estimate, I should think that with careful treatment, that is to say, good cultivation and pruning, and plucking by more modern methods, it ought to be possible to get nearly 450 pounds of made tea per acre without heavy manuring on well-grown matured tea using the fairly coarse plucking which is at present in vogue in Georgia. This, it will at once be recognised, is a relatively small yield when the quality of the tea is, at the best, only medium, and hence it is looked upon as very important that this yield should be increased by means of manuring. Hence large numbers of ex-

periments in manuring are being carried out both on mature and on young tea in various parts of the already planted area. As in most other places increase in yield follows very closely the amount of available nitrogen in the manure used, but the quantities used are very much greater than what we have been accustomed to consider normal in the Indian tea districts. It is probable, however, that manures, especially nitrogenous manures, will be quite cheap in Russia in the future, so that it will be possible to apply such manures on a very extended scale. It is hoped, in fact, (and I think the hope is a reasonable one), that a yield of between 600 and 700 pounds of made tea per acre on well-grown mature tea will ultimately be produced. The extensive use of *heavy* dressings of manure is one of the points in the plans for tea culture in Georgia which will place the industry in a rather different position from what would be expected otherwise.

At present, in Russia generally, there is a very great belief in the value of scientific assistance in connection with the development of industries, and in no industry is that value more emphasised than in the case of tea development. There has, in fact, been established already what is termed the "All-Union Tea Institute". This is really a large scientific institute for the study of the problems which tea culture in Georgia presents. The centre of the tea institute work is a very fine laboratory building situated at Osurgetti in the heart of the new tea areas, and it has branches furnished with small laboratories at two other centre namely, Chakwa, the original home of tea in Georgia, and at Zugdidi, the central point in the northern part of the districts. These centres are well supplied with highly trained scientific experts, from whose work we may expect very many results of great importance in the future. The matters which are being studied at present are of course, those which are specially important for tea in Georgia. Thus, for instance, a most elaborate study has been and is being made on the resistance of various types of plants to frost and quite important results have already been obtained. I expect that within a very few years it will be possible by mere inspection to mark down the plants which are likely to resist frost and also to be good yielders of leaf.

Again, in other parts of the world's tea area it has *not* been a matter of supreme importance to breed special types of tea plants, because many of the recognised *jats* of tea from India were extremely good, and suitable for almost all the conditions prevailing in India, Ceylon or Java. On the other hand, in a region like Georgia which is almost on the limits of tea cultivation, one of the most important matters of investigation is to find the most productive type of plants, which will stand the condition which prevail during the winter in the country. The development and growth of such plants, so as to produce as large a quantity of tea as possible to supply the needs of Georgia, is likely, of course, to be a matter of many years of work, but it is recognised that, though this is the case, it is essential that it should be proceeded with.

Moreover, it will be seen that the question of vegetative propagation takes on a new importance under these conditions. Of course, tea plants have been propagated vegetatively in Assam as well as in Ceylon and Java for many years, and has been the hobby of a considerable number of planters. I remember seeing accounts of work in this direction as far back as the seventies of the last century, but the matter has not been of vital importance where seed of good and reliable type, suitable to the circumstances, could always be obtained. Where this is not the case, the matter takes on a new importance and hence a considerable amount of study is being devoted to working out practical methods by means of which the plants can be propagated vegetatively on a commercial scale.

Another matter to which a good deal of study is being devoted is that of the best way in which erosion can be prevented in Georgian conditions. The matter is not so simple as seems to be the case at first sight, for any method adopted must be one which ultimately leads to the greatest economy of labour. In this, as in so many other matters, the question of labour economy is very important indeed.

It would be impossible here to indicate even in outline the lines of investigation which are being taken up with enthusiasm by the scientists now attached to the Institute in Georgia. On the

whole, now, the work is of a very much more practical character than it was when I first went to Georgia in 1930. Experience is being gained, and as a result the directions of research are being modified so as to deal more with the actual practical problems of tea cultivation and manufacture than was the case until recently.

In one matter I have particular admiration for the way in which the subject is being approached, namely the study of tea manufacture both as a scientific and a practical problem. In no direction does it seem that less progress has been made in tea study than in the knowledge of what actually goes on during tea manufacture. In spite of the large amount of study given to this matter in the last thirty years we are still very largely in ignorance of what happens during black tea manufacture, and what are the causes of the changes which take place. This problem is being approached now in Georgia by a group of men who, I feel confident, will make a very great deal of progress during the next few years.

Considered as a practical process, tea manufacture has, of course, enormously improved since the time when I first came into touch with it, but on the whole these advances have been in two directions. The first of these is on the engineering side, whereby the machinery then used has been replaced by far more economical and efficient types than was the case in those days. On the other hand, by the adoption of far more cleanliness in tea factories and by creating conditions of moisture and temperature under which both withering and fermenting proceed most favourably, a great deal has been done to bring tea manufacture under closer control than was formerly the case. But the Russian scientists, impelled again by the scarcity and expensiveness of labour, have already got the conception of tea manufacture as an entirely automatic process,—at least from the point at which the leaf leaves the withering houses, and they are proceeding with very active work with this aim in view. How far they will be successful, only time can show, but I should not be surprised that the entry of these efficient minds and sufficient enthusiasm into

this study may lead to developments which have hardly struck the imagination of workers hitherto.

This is not the place nor the time to give an estimate as to what will be the importance of Georgian tea cultivation in future to the world in general and to the old Indian tea industry in particular. It is still not clear how far the plans which have been made will be completely successful, that is to say how far the tea area, which it is planned to put out, will be of the yielding power which I have indicated as to be expected from good mature tea. But, it is, nevertheless, quite clear that with all the developments that *can* take place, in Georgia at any rate, Russia can never be entirely dependent, for its tea supply, on tea produced within its own borders. With increasing prosperity in Russia it is, hence, probable that the demand for tea from the rest of the world will never be less than it is at the present moment, so that Indian tea planters may look with interest and without concern on the development of tea cultivation in Georgia.

THE ACIDITY OF TEA SOILS OF NORTH EAST INDIA

Part II

The Treatment of soils of low acidity

BY

C. J. Harrison

Attention has previously been called to the influence of soil acidity on the growth of tea and it has been shown that tea fails to respond satisfactorily on soils of low acidity*. This is strikingly shown in the table at the end of this article giving the acidities of soils from different districts.

At the present time particularly, when efforts are being directed towards lowering costs of production, it is of importance to know firstly, what is the cause of unproductiveness of certain areas of tea, and secondly, when this is known, whether such steps as may be taken to improve the tea will be economically sound.

Many cases of poor tea are due to the low acidity of the soil, but in by no means all of these cases would the cost of treatment to increase the acidity to a satisfactory figure, be a paying proposition.

It is the object of this article to indicate the methods used in estimating the treatment required for soils of various types suffering from low acidity.

Soil acidity is due mainly to the presence of clay acids and organic acids present in a soil. Loss of acidity is due to the introduction of bases of various kinds (such as lime, magnesia or soda) so that when sufficient base is introduced into a soil to neutralise the acidity due to clay and organic acids, the soil loses its acidity and becomes neutral or alkaline, and unfit for tea.

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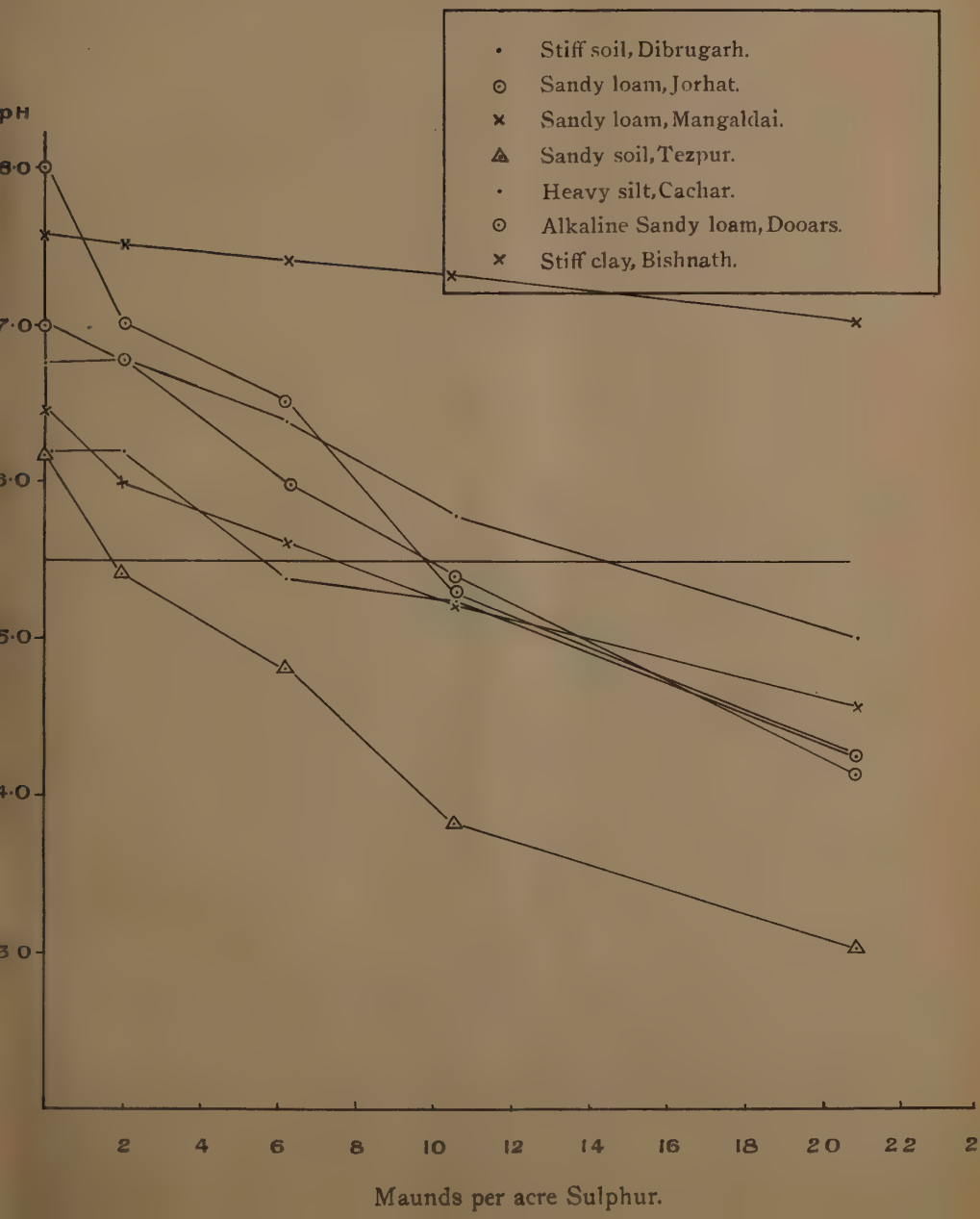
* Soil Acidity and the use of Lime on Tea soils by P. H. Carpenter, H. R. Cooper and C. R. Harler, *Indian Tea Association Quarterly Journal*, 1925, Part 1.

The Acdity of Tea Soils of North East India Part I by C. J. Harrison, *Indian Tea Association Quarterly Journal*, 1930, Part IV.

GRAPHS SHOWING INCREASE IN ACIDITY OF VARIOUS SOILS ON TREATMENT WITH SULPHUR.



A very sandy soil containing little clay or organic matter will require comparatively little base to make it neutral or alkaline while a stiff soil, or a peaty bheel requires much base to alter its acidity to any great extent.

This is illustrated by the following increases in pH (decrease in acidity) on soils of different clay and organic matter contents on the addition of lime equivalent to 4,000 lbs. per acre limestone.

Soil	Texture	Original pH	Final pH	Increase in pH
A	lightsand	5·1	6·5	1·4
B	sandy teela	5·15	6·8	1·65
C	stiff red soil	5·1	6·0	0·9
D	peat bheel	3·8	4·3	0·5

In order to increase the soil's acidity, something must be added to the soil which will combine with the bases present, so that they may be washed out of the soil by subsequent rainfall. If an acid, like sulphuric acid be added to a soil it combines with the lime forming calcium sulphate which is later leached out of the soil leaving the clay and organic acids in a free state. The soil thus increases in acidity. A sandy soil requiring little lime to lower its acidity, may require little acid to restore it again, while a clay soil requiring much lime to lower its acidity will require a large amount of acid to bring its acidity to a satisfactory figure. A stiff soil from Golaghat with a pH of 6.2 required four times as much acid to bring its acidity to 5.5, as a sandy loam of the same original pH from Tezpur.

The optimum acidity for the growth of tea is not definitely determined ; in fact it is likely to vary according to the nature and amount of clay or organic acid in a soil. Tea grows well on soils with a pH of about 4.0 to 5.8, and having a neutral salt extract pH of 3.5 to about 5.0. Light sandy soils and loams are seldom found

with a pH of less than 4.5. There are indications that a much higher acidity than this on sandy soils results in unsatisfactory growth of tea and may favour certain fungus diseases. Very stiff clays and especially peat bheels often have very high acidities, the pH being often in the neighbourhood of 3.5 to 4.0.

At the present state of our knowledge it may safely be said that any tea soil in North East India with a soil water pH of 6.0 or more, is definitely in need of treatment for increasing its acidity.

The method used at present, as a guide in determining the treatment required to increase a soil's acidity consists in treating equal portions of the air-dried soil with varying quantities of sulphuric acid of known strength, and estimating the pH of the resultant soil solution after 48 hours standing. From these results a graph showing the effect of acid on the soil pH is constructed. Taking pH 5.5 as representing a satisfactory soil acidity for tea, the amount of acid necessary to bring any soil to this pH is determined from the curve. Some representative curves are shown on the opposite page. Instead of giving the amounts of sulphuric acid used, the equivalent amount of sulphur in maunds per acre has been given.

The reason for this is that while it is impracticable to apply sulphuric acid to a soil, sulphur can be applied with ease in the same manner as any fertiliser. When in the soil under moist conditions sulphur is oxidised through the agency of certain soil bacteria to sulphuric acid which then combines with the bases in the soil, forming sulphates of lime, magnesia etc., which are quickly leached out leaving the soil more acid. The curves show that it is impossible to form any idea, from the original pH of the soil, of how much sulphur may be required to bring about the desired acidity. The horizontal line on the graph represents a pH of 5.5, taken as a normal figure for a good tea soil. This line cuts the various graphs at points corresponding to different amounts of sulphur. The table below gives the amounts

of sulphur calculated from the graphs as being sufficient to bring the acidity of each of the soils to 5.5.

Type of soil	District	Maunds per acre of sulphur required to bring soil to pH=5·5
Stiff yellow ...	Dibrugarh ...	14¼ mds.
Sandy loam ...	Jorhat	9¾ mds.
Sandy loam ...	Mangaldai ...	7¼ mds.
Sand	Tezpore	1¾ mds.
Flood silt	Cachar	5½ mds.
Alkaline sandy loam ...	Eastern Dooars ...	9¾ mds.
Stiff clay	Bishnath	.....

The stiff clay soil contains a very high percentage of bases and even 20 maunds of sulphur per acre is sufficient only to bring it to neutrality. Such a soil would certainly not pay to treat and would never grow tea well.

Though the sandy loam from the Dooars has a pH as high as 8.0, a degree of alkalinity not often met with in tea soils, it requires only the same amount of sulphur to turn it into a soil of satisfactory acidity, as the neutral sandy loam from the Jorhat district. The stiff soil from Dibrugarh, though slightly on the acid side of neutrality requires a larger amount of sulphur and at a cost of Rs. 6/- per maund for commercial flowers of sulphur the cost per acre to apply 14 maunds would be Rs. 84/- and it is hardly likely that at this figure a large area could be treated. On the other hand a soil like the Tezpur sand, the Cachar silt, or less alkaline sandy loams would well repay the cost of treatment. In fact an experiment on a Dooars grey sandy loam with a pH of 7.0 responded readily to a treatment of 5 maunds per acre of sulphur and the tea improved considerably after one year.

Apart from sulphur only one other general fertiliser, sulphate of ammonia, is known to produce an increase in soil acidity. One maund of sulphur is theoretically equivalent in acidity-increasing power to just over 4 maunds of sulphate of ammonia. As the normal dose of sulphate of ammonia is seldom more than two or three maunds, its acidity-increasing action, when applied for

the purpose of nitrogenous manuring is slow. On sandy soils such as those at Borbhetta very significant increases in acidity have resulted from three or four annual applications. Steady manuring with sulphate of ammonia over a period of years will gradually increase the soil acidity and convert a low acidity soil into one satisfactorily acid for tea. It may however be undesirable for reasons previously stated, to increase the soil acidity unduly and an alternation of one year of manuring with Calcium cyanamide (an alkaline manure), with two years of sulphate of ammonia, may be employed to keep the soil acidity at a steady figure.

In general, for all soils with a pH of over 6.0, except very sandy ones, tests should be made to determine how much sulphur is required to bring the acidity to a normal figure and if this is not too high the required amount of sulphur should be applied, in one dose or divided into two or possibly three annual doses.

With sandy soils of pH not more than about 6.5, three or four annual applications of sulphate of ammonia would cause a sufficiently large increase in acidity, though if quick results are wanted a single application of sulphur could be made.

It must be remembered that sulphur is not a fertiliser which supplies plant food to the soil and cannot therefore replace normal manuring. Its function is to correct low acidity.

District	Appendix 1 Mark	Hopkins acidity	pH of soil water extract	pH of mineral salt extract
Upper Assam	L. S. No. 8 good ...	63	6·0	5·0
	,, ,, 8 A bad ...	14	6·2	6·0
	,, good section ...	252	5·8	4·4
	,, bad section ...	77	6·1	5·0
	T. G. No. 1 good ...	490	5·8	4·4
	,, 6 bad ...	alkaline	6·6	7·4
	,, 18 good ...	1267	5·6	4·4
	,, 24 bad ...	alkaline	7·2	7·2
	E. W. No. 9 good ..	21	5·8	5·8
	,, 9 bad ...	0	6·0	6·4
	R. No. 7 poor ...	21	5·8	5·3
	,, 9 good ...	105	5·2	4·4
	,, 14 poor ...	7	5·8	5·6
	,, 17 good ...	441	5·4	4·2

District	Appendix 1 Mark	Hopkins acidity	pH of soil water extract	pH of mineral salt extract
	D. No. 1 good. ...	343	5·8	4·3
	„ 3 poor ...	63	6 0	5·0
	L. „ 1 poor ...	56	6·2	5·0
	„ 2 „ ...	7	7·4	6·6
	„ 3 „ ...	14	6·6	5·6
	„ 4 good ...	126	6·2	4·8
	„ 5 poor ...	14	7·0	6·3
	„ 6 good ...	679	5·8	4·0
Middle Assam	S. K. A good ...	642	5·6	4·15
	B bad ...	7	7·0	6·4
	S. poor ...	0	6·4	6·8
	T. R. A poor patch ...	4	6·4	6·7
	B „ „ ...	0	7·0	7·0
	C „ „ ...	alkaline	7·3	7·3
	normal tea	347	5·6	4·4
	K. K BN pura poor ...	7	6·2	6·6
	14 K better ...	21	6·0	6·2
	M. 5 good ...	352	5·4	4·5
	bad ...	6	6·4	6·4
	No. 12 Borjuri			
	good ...	166	5·8	6·4
	bad ...	3	6·4	4·6
	„ 4 good ...	581	5·6	4·2
	bad ...	28	6·0	5·2
	„ 6 good ...	287	5·7	4·4
	bad ...	14	6·1	5·6
	B.K. No. 2 good ...	42	6·0	5·2
	bad ...	14	6·2	5·6
	bad ...	28	6·0	5·2
	„ 13 good ...	249	5·8	4·5
	„ 17 good ...	114	5·8	4·7
	„ 8 good part ...	294	5·4	4·4
	„ 8 bad part ...	27	5·8	4·6
	„ 4 bad ...	alkaline	7·2	7·2
	N. E. bad ...	7	6·0	6·2
	A. L. 5 C. R.			
	good ...	568	5·5	3·9
	bad ...	21	6·0	4·7
Lower Assam	M. J. bad	515	6·1	.....
	better	353	5·7	.....
	N. G. No. 2 good	77	5·4	4·9
	bad	7	5·8	6.6
	A. good	21	6·2	5·8
	B. „	11	6·4	6·1
	A. bad	11	6·2	6·1
	B. „	7	6·2	6·4

District	Appendix 1 Mark	Hopkins acidity	pH of soil water extract	pH of mineral salt extract
	P. B. No. 12 good ...	96	6·1	.....
	„ 12 medium ...	265	6·0	4·5
	„ 12 bad	44	6·3	.....
	„ 12 bad ...	51	6·5	5·3
	K. G. good	alkaline	6·0	6·6
	better	42	6·0	5·6
Surma Valley	C. P. No. 3 tea will not grow ...	14	6·0	4·6
	„ 4 tea dying ...	11	6·1	4·7
	„ 7 tea will not grow ...	7	6·1	4·7
	P. L. lime flat good ...	2188	5·2	3·8
	Banskal bad ...	14	6·2	4·7
	„ bad ...	39	5·9	4·4
	lime flat bad ...	32	6·0	4·4
	A. good	1997	5·7	3·9
	B. bad	14	6·8	6·0
	B. R. poorish	0	6·3	6·8
	good	14	6·0	6·1
	C. G. 3 C. N. E. tea dying ...	7	6·2	5·0
	6 C. E. N.	7	6·8	5·6
	6 C. E. M. poor ...	0	6·4	6·2
	6 C. E. S. good ...	3378	5·2	3·9
	9 teela medium tea ...	1446	5·4	.....
	S. P. good	189	5·7	4·2
	poor	14	6 0	6·0
	T. K. 93 E good	2954	5·4	3·6
	93 W poor	875	5·6	4·0
	86 E good	2597	5·4	3·8
	86 poor	6·09	5·5	4·2
	88 good	2156	5·3	3·9
	poor	623	5·6	4·1
	89 good	4375	5·0	3·6
	poor	798	5·4	4·1
	P. bheel good	3345	4·6	3·6
	poor	2144	4·7	3·9
	bad & partly abandoned	63	5·0	5·2
Surma Valley	T. B. bushes dying ...	7	6·2	6·6
	bushes made no growth ...	14	6·0	5·6
	some growth ...	112	5·8	4·9
	very healthy ...	133	5·8	4·8
Dooars ...	W. B. bad	28	.....	.....
	good	394	.....	.....
	D. N. fertile	21	5·8	5·4
	infertile	alkaline	6·9	7·4
	B. P. N. fairly good ...	292	5·8	4·5
	poor	7	6·2	5·9

District	Appendix 1 Mark	Hopkins acidity	pH of soil water extract	pH of mineral salt extract
	J. B. P. No. 50 infertile ...	0	6·1	6·9
	No. 49 good tea ...	63	5·6	4·8
	R. B. C 3 bad	14	7·0	5·1
	D 3 good ...	104	6·6	4·3
	J 3 infertile ...	4	6·2	6·6
	Y 3 bushes dead ...	4	6·0	6·5
	E 3 good tea ...	53	5·4	4·6
	T. R. No. 20 good ...	22	6·0	5·8
	bad	9	7·1	6·6
	tea died out ...	alkaline	7·4	7·3
	poor ...	0	7·3	7·0
	poor ...	9	6·6	6·4
Terai and Darjeeling	S. H. No. 5 A bad ...	14	6·2	6·0
	,, good ...	566	5·4	4·2
	B. G. poor tea bad mosquito ...	42	5·6	5·1
	good tea no mosquito ...	175	5·5	4·6
	L. H. No. 6 good	525	5·1	4·4
	,, bad	28	5·9	5·4

TEA TASTERS' TERMS

BY

C. R. HARLER

The quality of tea is judged by the tea taster on whose report the sample is valued. In assessing this value, account is taken of the appearance of the tea, the colour of the infused leaf and the properties of the infusion. The last is the most important in the majority of teas.

For many years chemists have tried to find some relationship between the analysis of a tea infusion and the quality and value of the tea as indicated by the taster. No appreciable correlation has been obtained, which indicates that a chemical analysis, carried out according to present methods, is not sufficiently discriminating. Thus, to illustrate one direction in which an analysis is inadequate, all the tannin bodies in a tea infusion are estimated as a group and returned as "tannin". It is known that the tea tannin in an infusion is present in several modifications, which are responsible wholly or in part for such cup qualities as *rawness, briskness, pungency, strength, colour* and *thickness*. It is hence obvious that an estimation which combines all these qualities, irrespective of their relative proportions, can be of little use in evaluating a liquor.

The analyst will never be able to compete with or replace the tea taster but, in spite of this, a tea analysis, if it distinguished teas according to their quality, would be of great use. By means of such an analysis the changes occurring in the tea leaf during manufacture could be followed, and used as a basis for recommendations regarding factory procedure. A complete analysis would also indicate ultimate differences between teas from various districts, and useful conclusions might be drawn regarding methods in different areas.

With the help of the tea taster, much empirical knowledge relating to the effect of factory methods on the finished product has been gained. In the present discussion it is proposed to outline

evident that only the commoner, well defined expressions can be the effect of leaf and factory conditions on the tea made, and then with the influence of various conditions in withering, rolling, fermentation and firing on the finished commodity.

The discussion is summarised in a glossary of terms used by tea tasters in describing teas. A great variety of expressions is employed by tasters, some of which are peculiar to certain men or offices. On the other hand, some tasters indicate one characteristic and some another by the same term. It is therefore evident that only the commoner, well defined expressions can be included in a short glossary.

Most of the tasters' terms refer to shortcoming or bad characteristics in tea. It will be observed, on reading below, that most faults in tea may be developed at any stage in manufacture. For example, *dull* infused leaf may be due to poor leaf, overwithering, over fermentation or incorrect firing. It is thus not an easy matter to trace a fault to its source and still harder to rectify it since many of the commoner faults result, indirectly, from a shortage of labour, space or machinery.

In discussing the influence of manufacture on the finished tea, the tasters' terms are used in a relative sense. Thus, at various periods during the season the leaf is such that the tea made will not give bright infused leaf as judged by an absolute standard. But there are degrees of dullness, and such leaf carefully manufactured will give infusions which are *bright* by comparison with the same leaf badly manufactured.

Leaf and factory equipment.

The influence of fine leaf on quality has been fully discussed in a previous *Journal* (1). It suffices here to say that without fine leaf quality tea cannot be made. On the other hand it certainly pays to manufacture carefully and to make the best of poor leaf (*i.e.*, tippings, coarse leaf, leaf plucked on a long growth, *banjhi* leaf and hard leaf), although in practice it is noticed that where such

(1) "Plucking for Quality", *Quar. Jour. Ind. Tea Assn.*, Calcutta, 1931 (pt. 2).

leaf is plucked, factory conditions are generally against the making of the best of the leaf.

The liquors of tea made from poor leaf are often described as *thin, washy* or *weak* and *plain* or *coarse* in character. Careful manufacture reduces the degree of these undesirable qualities. Fine leaf may give teas possessing *raw, rasping* or *harsh* liquors, qualities which indicate under withering, under fermentation, but generally under rolling.

Flavour and *aroma* are evanescent qualities which are apparent at certain times of the year, and are marked in North East India in the second flush and autumnal teas. Sometimes to indicate the presence of a touch of flavour the tea is described as having a good *nose*. How to produce flavour is not known, neither are the conditions of manufacture which would destroy flavour already in the leaf. When the green fly effect is present and the distances between leaves on the shoot are very short, the third leaf, which will give flavour, should be plucked. The infused leaf of good second flush tea is often *copper* coloured.

Second flush flavour is greatly influenced by weather conditions. For marked flavour the bushes must be in such condition that the tippings, which comprise very poor leaf, should be practically finished and the plucking surface of the bush completely made before the second flush appears. Further, conditions should be such that the third flush does not come early enough, or in sufficient quantity, to influence the second. The best second flush tea is made when growing conditions ensure that the leaf consists predominantly of the second flush.

In the rains, fine leaf and careful manufacture give teas highly valued for *colour, strength, thickness* and *pungency*. The present paper deals mainly with these qualities and points out the many places in manufacture where they can be impaired or lost.

In the factory, adequate space and machinery, and low temperatures during withering, rolling and fermentation, are essential to make the best of the leaf plucked. It is generally necessary to use some form of humidification in the fermenting and rolling rooms to produce low temperatures.

So far as conditions in North East India are concerned, withering space equal to not less than 22 sq. feet per maund of tea made in the season should be available. Gardens producing the best teas are usually equipped with much more space than this.

One roller for each 900 maunds of tea made in the season is necessary, and power sufficient to run the rollers at pressure should be provided. The rollers, leaf trolleys and every place where the leaf is placed should be kept scrupulously clean, otherwise there is a risk of infection by harmful bacteria, which, besides producing *taints,* may also be responsible for *dull* infusions and infused leaf. The development of moulds in fermenting leaf is said to produce a mouldy smell in the tea, *light* to yellow liquors, *dark* infusions and a decidedly objectionable taste (2).

In order to fire properly, one large Empire per 6,000 maunds or one large E. C. P. Dryer per 4,700 maunds tea made in the season should be available for the first fire. Suitable second firing machines to fit these should be installed. In the former case a 10 ft. Venetian and in the latter a double Tilting Tray machine is adequate. A Paragon Dryer can also second fire the leaf from either of the big machines.

The power required to run a factory capable of dealing with 10,000 maunds is 120 to 150 B. H. P. (3).

On the average garden in the Brahmaputra Valley, the factory is equipped to deal with a crop of about 8 maunds per acre. In the Dooars and Surma Valley the equipment is generally sufficient for less than this. The scale of manuring practised in recent years in North East India has produced crops often beyond the capacity of the labour force and the factory, with a resultant falling off in the quality of the tea. This loss of quality is not infrequently wrongly attributed to the use of artificial manures.

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(2) K. A. R. Bosscha and A. Brzeskowsky, *Med. Proef. Thee.,* Buitenzorg, 1916 (No. 47).

(3) For fuller details reference should be made to "Factory Requirements for the Making of Good Tea", *Quar. Jour. Ind. Tea Assn.,* Calcutta, 1929 (pt. 1).

Withering.

To make the best possible tea from the leaf available, the latter must be withered evenly, slowly, and at a low temperature. In the rains a good wither is obtained when 100 lbs. leaf dry to about 65 lbs. in about 22 hours at a temperature ranging from 75° to 85°F. Coarse leaf must be withered more slowly than fine leaf in order to ensure an even wither. In no case should the leaf be withered in less than 16 hours.

It is common in the rains for leaf to wither only 75 or 80% (100 lbs. drying to 75 or 80 lbs.). Such leaf is smashed up on rolling and gives a *flaky* tea. To fire low-withered leaf, it is often necessary to raise the firing temperature in order that the drying machine shall be able to cope with the leaf as it is brought from the fermenting room to be fired. High firing temperatures on very wet leaf often produce a *brownish* tea. Brownishness can be avoided by firing the leaf slowly at normal temperatures (180°F.), although the drying machinery in most factories is insufficient for this during a wet spell, when withering conditions are difficult.

When under-withered leaf is rolled and spread on the fermenting floor, the colour is usually bright, owing to the high water content of leaf. A similar effect can be obtained by spraying fermenting leaf with water. Although the leaf on the floor has a bright colour this is no guarantee that the infused tea leaf will have a good colour. Indeed, the infused leaf of tea made from under-withered leaf, although it may be *bright,* is generally *greenish.* The infusions from such leaf are often *raw* and *harsh.*

In order to make the best of leaf it is not sufficient to wither the bulk to a certain degree of dryness. The wither must be even throughout the shoot. If the wither proceeds too rapidly, the thin leaves may over-wither and blacken whilst the bud and stalk remain under-withered. Such leaf when manufactured gives *uneven* infused leaf, containing dark coloured pieces which represent those parts of the shoot blackened in withering. Over-withered leaf will not ferment well owing to its dryness, and hence tends to produce *thin* liquors.

Uneven withering may be due to the use of wire withering racks, where part of the shoot hangs through the mesh. In such cases the bud often protrudes and is over-withered, with the result that *silver tip* appears in the tea. The reason for this is that fermented tea juice, which is yellowish, does not easily stick to the hairs of the dry bud and the latter then appear white or silver in the finished tea.

The most suitable degree of wither varies with the atmospheric temperature, and in hot spells when the thermometer rises to the neighbourhood of 100°F., the leaf reddens on the racks if it is withered to 65%. The tea made from red leaf gives *thin* liquors and *dull* coloured infused leaf. This also applies to leaf which has turned red in the plucking basket.

On the time taken to wither depends the period necessary for fermentation, and the lighter the wither the longer should be this period. Thus, at Tocklai it was observed that leaf withered to 58% (100 lbs. dried to 58 lbs.) in 6 hours required 4½ hours fermentation; similar leaf withered to 62% in 20 hours required 4 hours fermentation; similar leaf withered to 60 lbs. in 42 hours required only 3½ hours fermentation. It is possible partly to overcome the effects of an under-wither by increasing the time of fermentation.

The following faults may be associated with under-withering : *flaky* leaf, *raw* or *harsh* liquors, and infused leaf which is *greenish* in colour and *open* in appearance. With uneven withering, the infused leaf will be *uneven* or *mixed,* and the liquors *thin*. Correctly withered leaf, if subsequently treated properly, makes for *black, well-twisted* leaf, a *mature* tea, giving *bright* infused leaf and *strong* liquors (4).

Rolling.

The leaf during rolling should be kept as cool as possible, and it is recommended that the rolling room temperature should not be above 80°F. In rolling, especially in the first roll when the fine leaf is present, the bulk of the leaf heats up several degrees even though the pressure cap

(4) For a fuller discussion on the subject of withering see "The Withering of Tea Leaf", *Quar. Jour. Ind. Tea Assn.*, Calcutta, 1930 (pt. 4).

of the roller is not down. This heat is mainly due to fermentation and not friction. The coarse leaf, although rolled with pressure does not heat up so much as the fine leaf, because its rate of fermentation is much slower.

After the first green sift and the removal of the fine leaf the second and third rolls should be with pressure, the cap being alternately raised and lowered. The pressure roll should be broken by a green sift which cools the leaf and also hastens the oxidation.

Rolling influences the appearance of the tea and also the strength of the liquors. Hard rolling makes for *strong, thick* liquors which cream (provided the leaf is fine) and, generally speaking, the lighter the degree of the wither the harder must be the rolling pressure to produce these qualities. Hard rolling may destroy the tip in the tea either by rubbing off the hair from the fine leaf or by closely matting it with tea juice.

Too hard rolling rubs the outside skin off the *stalk* and exposes the same. Coarse leaf is more liable to show stalk than fine and, in addition, it is usual for a tea taster to remark on a certain amount of stalk in a poor tea which, in a good tea, would pass unchallenged. The presence of some stalk is indicated by the term *some ends*.

On account of the generation of heat, the rolling period should be as short as possible. In order to realise this and to damage the leaf sufficiently to ensure full fermentation, the speed of the roller should be about 60 to 70 r. p. m., during the hot weather. In the spring and autumn when temperatures are lower and, on account of the dry atmosphere, a very full wither can be obtained, the rolling speed may be slower, although the rolling period must be proportionately lengthened. Thus, during the hot weather when the rollers make, for example, 70 r. p. m., a suitable rolling system consists of 3 thirty-minute periods, or a total of 90 minutes. If, during the cool weather, the rolling speed is reduced to 50 r. p. m., the total period should be increased to $90 \times 70/50 = 126$ minutes. In this way the same number of revolutions is given at both speeds.

The development of high temperatures in rolling makes for *thin* liquors with *dull* coloured infused leaf. In fact high temperatures at any time during manufacture tend to produce these qualities.

Fermentation.

The main chemical reactions taking place during the fermentation of tea consist of changes in the tea tannin and the formation of the tea essential oil. By the aid of an enzyme, the tannin is rapidly oxidised to red substances as soon as the tea juice is exposed to the air. Condensation of the tannin molecule may also take place, producing other red and brown substances.

As the tannin changes, so its tanning power, or ability to precipitate proteins, increases. Tea tannin as it exists in fresh or withered leaf cannot precipitate gelatine (a protein) from dilute solution. Tea tannin is therefore designated a pseudo-tannin.

When tea tannin is oxidised, however, the power to precipitate proteins, which is a property of true tannins, is developed. Since fresh tea leaf contains about 15% proteins (on the dry matter) it follows that as the tea tannin is oxidised so these proteins will be precipitated if brought into contact with the oxidised tannin. The insoluble compound so formed is chemically related to ordinary leather. The formation of such a compound in tea has not yet been definitely proved, but evidence of its existence is available. Much of the oxidised tannin formed during the fermentation of tea leaf is thus fixed within the tea leaf and never enters a tea infusion. Prolonged boiling with water fails to decompose the compound of oxidised tea tannin and leaf proteins, and the blackish green colour of spent tea leaf is no doubt due to this substance.

As tea fermentation proceeds, the tannin is progressively oxidised, precipitated by leaf proteins and rendered insoluble. This continues for about 4 or 5 hours, during which time the soluble tannin content may fall from 20% to 10% (5). After this, little further change in the tannin content takes place, possibly

(5) These, and subsequent tannin values are those given by the Loewenthal estimation, using a conversion factor of 0.0416.

because there is no leaf protein left to effect further precipitation. The tannin which remains soluble is a mixture of the original pseudo-tannin and various products of oxidation and condensation. These substances enter the tea infusion and give it certain properties.

A knowledge of the changes just described is at present of little assistance in the practical control of fermentation. In this process all our knowledge has been gained by hit-or-miss methods, the general results of which may now be indicated.

Tea leaf fermented for too short a period (*e.g.*, 2½ hours, including the rolling period) gives tea with liquors *raw* or *harsh* in taste and *weak*, *light*, *washy* or *thin* in body. The infused leaf has a *greenish* colour. Such tea may contain, say, 15% tannin. As fermentation proceeds the rawness gives place to *pungency* or *briskness*, the liquors become redder and *thicker*, and *strength* develops. Strength is apparently a combination of pungency and thickness. Such a tea gives a *bright*, red coloured infused leaf and on cooling, the infusion gives a precipitate, known as the *cream*. At this stage (about 3½ hours total fermentation) the tea contains about 10% to 12% tannin. Further fermentation produces a *flat* tea which has lost its pungency or briskness and gives liquors which are *dull* and brownish in colour. On cooling, a *dull*, *murky* precipitate forms and the infused leaf is *dull* in colour. Although this tea contains only slightly less tannin than the strong tea fermented about 3½ hours, certain important chemical changes have taken place, the exact nature of which is unknown at present.

Exceptions occur to the above, of course, and the statements made only have a very general significance.

In the present state of our knowledge, the time of fermentation most suitable must be decided by empirical methods. Generally speaking, if leaf is withered and rolled as recommended above and spread in the fermenting room about 1½ to 2 inches thick, in an atmosphere which is cool (about 80°F.) and humid, then fermentation will have proceeded to its optimum in 3 to 4 hours, including the rolling period.

Firing and Sorting.

Although fairly definite information is available on the subject of firing, this process is the most difficult to carry out because of the constant adjustment of the dryer necessitated with the ever changing state of the leaf, and the rate at which it comes from the fermenting room. Thin-slow-low, are the maxims for firing tea. The leaf must be spread thinly on the trays, as thin as the automatic spreader allows. The leaf should pass through the first machine slowly, in not less than 20 minutes, preferably 25. The firing temperature should be low, 180°F.

In addition, it is essential to drop the tea from the first fire at least "12-annas" dry. The temperature below the top tray of the dryer should be 140°F. Unless these conditions are observed, the fermentation process is not rapidly stopped and continues for some time in the dryer. As a result the tea loses pungency and gives *soft* liquors, with *dull* coloured infused leaf. The tea may also be pronounced *stewed* or *sweaty*, which terms apparently indicate a lack or shortage of tea characteristics, probably the tea essential oil. *Sweaty* may also refer to some taint in the tea, following over-fermentation on a dirty floor (6).

Unless the leaf is dried slowly and evenly in the first fire it may be case-hardened, as a result of which the centre of the leaf is much moister than the outside. During the second firing the moisture thus imprisoned within the leaf on escaping may *blister* the tea. An additional fault which comes from rapid drying is the formation of a layer of microscopic bubbles on the surface of the leaf. On sorting, these bubbles may have the heads rubbed off exposing a *grey* surface. Although teas from North East India all show a certain amount of greyness, this property can, in extreme cases, reduce the value of the commodity.

The second fire is very important in that here the leaf is submitted to heat whilst it is dry, and on this account gets its keeping qualities. A full "16-annas" fire is necessary in the second firing machine, otherwise the tea is likely to *go-off* on storing.

(6) For further details regarding firing see "The Firing of Tea" *Quar. Jour. Ind. Tea Assn.*, Calcutta, 1930 (pt. 2).

Tea should not be kept in the drying machine after it is fully dried but should be discharged as soon as it has reached 16-annas, or it may be *high-fired* if the initial firing temperature is above 200°F. If the temperature is below 200°F., such treatment produces what is termed a *dry* tea. Tea which is put into an empty or incompletely filled dryer is liable to be fully dried when it is about than half way through the machine, and will pass along the last two or three trays in a dry condition, with the results just indicated. By the time a tea reaches Home, a touch of the fire may disappear, but *dryness* in a tea persists.

Tea is sometimes described as *bakey,* an expression which may denote slight high firing. The term *malty* probably has the same significance.

Too much sorting and cutting produce *greyness,* and may partially destroy the tip. Tea should not be sorted immediately it is fired, but preferably the next day, after it has picked up some moisture from the atmosphere. It is then less brittle and less liable to *grey*. If tea is cut too much, in order to produce a broken grade, it may be called *choppy*. A broken tea should be broken in rolling and not in the cutting machine. A Broken Pekoe Souchong should have a shell-like appearance, which is described sometimes as *crepy*.

The grading of a tea assumes most importance when the liquors are poor. Then the grade must be true to type, *even* and *clean*. Cleanliness in the leaf refers to the absence of dust and fibre. It is sometimes the practice to add a small percentage of dust or fannings to a grade tea in order to strengthen the liquors. Although this object is achieved, something is lost in the valuation owing to the presence of the finer particles.

Tea should be packed with a moisture of not more than 6%, otherwise it may *go-off* on keeping. On the other hand tea may not be packed in too dry a state or it will not *mature* on keeping, but retain its original slight harshness. Such teas may be described as *new,* although this term is a rare one.

A Glossary of Tea Tasters' Terms

Below is a glossary of the commoner terms employed by tea tasters in describing teas from North East India. The list does not pretend to completeness and only terms which are used in their ordinary sense are shown, for there are a good number of terms used by individual tasters which convey little or nothing to the average tea planter. Thus, in one case, a tea infusion was described as tasting like a "bandsman's tunic". Such an expression connotes unpleasantness, and may denote sweatiness, but gives no definite guidance to a planter who wants to trace a shortcoming in his tea to some incorrect factory procedure.

Several very useful and expressive terms in common use are difficult to define. Thus the exact significance of *quality* we have been unable to discover, for it seems to denote all round desirability or the presence of some flavour, although not enough to warrant the description of "flavoury". Exactly how quality is obtained or destroyed we cannot say, but it is evident that only fine leaf gives quality teas.

Another term which is frequently met is *point*. This cannot be tied down to any particular property but some tasters use it to denote any characteristic, *strength, briskness, pungency,* which is sufficiently marked in a tea to carry that property into a blend.

The exact meaning of *briskness* as applied to tea is difficult to determine. Most tasters use it to denote a *live* liquor as opposed to a *flat* one, but whether it indicates a degree of pungency we cannot say. The terms *live* and *flat* are here used as they are in describing a freshly opened soda water and soda water which has been allowed to stand for some time. *Pungency* is a characteristic of Assam teas and is seldom met in those from the Dooars and Surma Valley, which teas are usually *brisk*. *Pungency* is only shown by teas made from really fine leaf.

Many terms appear to be used to denote the same property or slight variations of a property. Thus *washy, weak, thin, light* and *sweet* describe various degrees of thinness, the first two terms

representing something undesirable. The last two terms may be used to describe good liquors, although not so good as those showing thickness and strength.

The expression *sweetish* may denote a tea which has some undesirable quality, perhaps a taint. *Fruity* expresses a similar characteristic and suggests over-fermentation on a dirty fermenting space.

The terms *full, round, smooth* and *mature* all indicate an absence of bitterness or rawness and suggest strength. Such teas usually cream down well. Fullness gradually gives place to *softness* and then *flatness.*

The terms in the glossary below, which includes 65 in all, are collected under four headings dealing with the appearance of the tea, the infused leaf, the infusions or liquors, and general characteristics. Particular manufacturing conditions which may account for some of the faulty characteristics are denoted. Most of the terms are to be found in the body of the text above and are discussed in that process of manufacture in which the characteristic they describe is formed. As an aid to reference the tea tasters' terms in the text are printed in italics.

1. The leaf (indicating the appearance of the tea).

Brownish—Leaf which is brown in colour. Underwithered leaf fired at too high a temperature makes brownish tea.

Blisted—Leaf swollen and hollow inside. Results from too rapid firing.

Black—Leaf which is black in colour. Fully withered leaf gives black tea.

Choppy—Leaf chopped in the breaker or cutter rather than broken in the roller.

Clean—Leaf free from fibre and dust.

Crepy—Usually applied to a Souchong with shell-like, crimped leaf.

Even—Leaf true to grade and consisting of pieces of roughly equal size.

Flaky—Leaf not twisted, but in flakes. Results from hard rolling under-withered leaf.

Grey—Leaf grey in colour. Results from too rapid firing or too much rubbing in sorting and cutting.

Silver tip—Grey coloured tip. Leaf which has been over-withered usually gives grey tip.

Some ends—Some stalk.

Stalk—Usually indicates red stalk. Results from coarse leaf and too hard rolling.

Tippy—Containing a large percentage of golden tip. The tip is due to the hair on the buds and young leaves.

Uneven—Tea composed of uneven pieces.

Well-twisted—Fully withered leaf gives well-twisted tea.

2. The infusion (indicating infused leaf).

Bright—Bright red in colour, denoting a good tea. The liquors of such infusions are usually bright.

Coppery—Bright, copper-coloured infusion. Often given by second flush teas.

Dull—Brownish in colour, denoting a poor tea. Results from over withering or over fermentation. The liquors of such infusions are usually dull.

Green—Greenish in colour. Results from under withering, under fermentation or insufficient rolling. The liquors of such infusions are raw or thin according to the fineness or coarseness of the leaf.

Open—The infusion has lost its twist. Results from under withered leaf or insufficient rolling.

Mixed—The infusion contains red, green and black colours. Results from uneven withering, fermentation or rolling.

Uneven—see *Mixed*.

3. The liquor (indicating the tea infusion).

Brisk—Having a "live" characteristic. Showing some degree of pungency.

Bright—Bright in colour and clear, with some thickness.

Body—see *Thick*.

Colour—Denotes good colour, *i.e.*, bright, red and clear.

Dull—Brownish liquors which are not clear or bright. May result from over withering, over fermentation or incorrect firing.

Flat—Lacking in briskness and pungency. Results from over withering, over fermentation or incorrect firing.

Fruity—Suggests a taint. May be due to over fermentation on an unclean floor.

Full—A strong tea with no bitterness. One which will cream down well.

Harsh—An infusion which is bitter. Results from under withering, under fermentation, but generally from under rolling.

Light—see *Thin*.

Malty—Suggests slight high firing.

Mature—No rawness or flatness.

Murky—see *Dull*.

Pungent—Having astringency without bitterness.

Raw—see *Harsh*.

Rasping—see *Harsh*.

Round—see *Full*.

Smooth—see *Full*.

Strength—A combination of thick liquors and pungency or briskness. A tea which creams down well.

Soft—see *Flat*.

Sweet—A light liquor that is not altogether undesirable.

Sweetish—Suggests a taint. May result from over fermentation on an unclean floor.

Thick—A concentrated, bright red infusion which creams down well.

Thin—A dilute infusion. May result from under withering, under fermentation and not enough rolling. Usually results from poor leaf. High temperatures during manufacture produce thin liquors.

Weak—Thin and lacking in pungency. See *Thin*.

Washy—see *Thin*.

4. General characteristics.

Aroma—Usually denotes the presence of flavour.

Bakey—A slightly high-fired tea.

Coarse—A liquor which may have some thickness but is deficient in tea characteristics. Results from coarse leaf.

Cream—The precipitate obtained as soon as a strong tea cools.

Dry—A characteristic in the liquor which is evident when tea is not discharged from the dryer as soon as it is fully fired.

Flavour—A tea showing a seasonal or district flavour.

Gone-off—A mouldy or tainted tea. May arise from the use of a dirty fermenting floor or roller, or from packing tea with too much moisture.

High-fired—A burnt tea. Indicates that tea has been kept in the second firing machine at 200°F., or more, after it is fully dried.

Malty—A slightly high-fired tea.

New—A tea which has not had time to mellow. Usually denotes slight rawness or harshness in the infusion, which may disappear when the tea is kept some time.

Nose—Indicating some aroma in the tea.

Plain—Lacking in tea characteristics. Usually results from coarse leaf.

Point—Some marked desirable characteristic.

Quality—Denotes the presence of desirable characteristics.

Stewed—A tea lacking in the common tea flavour. Results from firing to less than 12-annas in the first fire and to too low temperatures below the top tray of the firing machine.

Sweaty—see *Tainted*. May result from over fermentation on an unclean floor.

Tainted—A tea having a strange flavour. May result from infection by micro-organisms at some stage of manufacture or on keeping. Usually refers to some flavour quite foreign to tea, *e.g.*, oranges, onions, kerosine.

THE PRODUCTION OF GOLDEN TIP

BY

S. F. Benton

Tip is required in teas chiefly on account of its appearance, and although it may add little or nothing to the liquor, it is in the interests of the garden to see that the maximum amount of tip is retained during the manufacturing process. To command the highest price, tip must also be of the correct colour.

Tip is generally held to consist of the buds of the tea shoot, but it is not always recognised that it is possible to have buds without the appearance of tip, and also tip which consists of the second leaf and to some extent, the upper portion of the stem. The latter types, being larger and more wiry, frequently make up a considerable percentage of the tip in orange pekoes.

Origin of Tip. When fresh shoots are examined microscopically, the upper portion is frequently found to be covered with fine silvery hairs, averaging $\frac{1}{75}$ inch in length and $\frac{1}{1000}$ inch in thickness. In some instances the hairs are confined to the bud, while in others hair development extends over the first leaf and down the stem. The number of hairs varies to some extent with the season, and with others factors which are not yet established. Hair formation appears to be more pronounced in dry weather, which probably accounts for the tippy appearance of second flush teas, and the marketing of Flowery Orange Pekoes at this period.

It is also very evident that the tendency to produce hairs on the young shoot varies considerably among the different jats of tea. Since tip cannot be made if these hairs are not present, the production of tip is in some cases outside the control of the planter.

The production of tip.

When leaf is withered, moisture is lost, and consequently the cell sap becomes concentrated. Rolling expresses the sap in the form of a sticky juice which is deposited on the hairs of the bud, binding them together. It is as yet uncertain whether the hairs

actually absorb the juice, but this does not appear to be a matter of great importance. On fermentation, the ordinary copper colour of fermented tea develops in the juice, and when the leaf is fired, loss of moisture leads to contraction of the leaf tissues, the hairs subsequently appearing as a thick mat, bound together with dried juice. It is probable that caramelisation of some of the constituents of the juice takes place, emphasising the golden colour.

It is thus clear that the factors necessary for the production of tip are :

(1). The presence of hairs on the shoot.

(2). The expression of sufficient juice to coat these hairs.

(3). The development of a golden colour in this juice through fermentation and firing.

Defects in Tip.

Even when the withered leaf shows a marked "bloom", *i.e.*, when hair development on the upper part of the shoot is adequate, tip of the required golden colour may not be produced, and tip may also be lost during the process of manufacture. The principal defects are silver tip, dull tip, dark coloured tip and small tip. The first three may be put down to manufacturing conditions, while the fourth is largely outside the Manager's control.

Silver Tip. In hot dry periods the true golden colour may not be developed and the value of the teas may be depreciated in consequence. True silver tip arises as a result of an over-wither, and must be distinguished from "dull tip" which has its origin in abrasion of the hairs. If the loss of moisture during withering is allowed to proceed beyond the optimum, the leaf may become too dry to permit the expression of juice during a light first roll. Since the development of a golden colour is dependent on the deposition of juice on the hairs, absence of juice enables the hairs to exhibit their natural silvery colour in the finished pro-

duct. Light rolling of high withered tea may distort the leaf cells sufficiently to induce fermentation without actually moistening the outside of the leaf to any marked extent.

It is quite safe, and in fact desirable, to apply pressure in the first roll when dealing with highly withered leaf, provided that the speed of the rollers is not excessive. 55 r. p.m. is a satisfactory speed. After the first roll, the leaf should have a distinctly moist or sticky feeling, and if necessary, pressure should be utilised to secure this effect.

It is also possible to obtain silver tip to a lesser degree from a very kutcha wither, when juice may appear in large quantities during a light first roll. Such juice may be deficient in soluble solids, and may therefore fail to leave a thick coating over the hairs when firing is complete.

True silver tip may be readily recognised under a low power microscope, when the black leaf tissue is seen to be completely obscured by hairs, the absence of dried juice revealing the silvery colour of the hairs themselves.

Dull tip. Rough handling during manufacture or sorting may result in the abrasion of the hairs on the bud. If the remaining hairs are insufficient in number to cover completely the black tissues of the fired leaf, a dull or greyish colour will be presented to the eye, owing to the minute size of the hairs and of the spaces between them. Under the microscope this effect is very clear. The greyish or silvery appearance is more common, since the abrasion of the hairs is usually brought about during sorting, and this also tends to remove the larger particles of dried juice clinging to the hairs, to which the golden colour of tip is largely due.

Dark Coloured tip. While tip is usually a bright gold it is occasionally found with a deep brownish red colour. This condition appears to be the complement of dull infused leaf, and to have its origin in a bacterial infection, which induces the production of dark tannin bodies during fermentation. The modern

methods of eliminating infection have been found effective in dealing with this defect.

Small tip. At certain times of the year, and in certain jats of tea, hair production is greatly restricted, being confined to the midrib of the bud and to banji buds. It is obvious that tippy teas cannot be made when this is the case, and the most careful manufacture can only produce fragments of tip arising from banji buds, and black tips with streak of gold when hair occurs only on the midrib.

There is however a further possibility to be considered, that if inlet temperatures well in excess of 212° are employed in the first firing machine, charring of the hairs may occur, since their exposed position leads to rapid drying.

Loss of Tip during Manufacture.

Tip can be lost during manufacture by any process which submits the hairs to excessive friction. Before firing, a relatively strong shearing force is required to remove the hairs, but in the dry state friction should be avoided at all costs.

Abrasion during rolling.

Fast rolling is an important factor in the loss of tip, particularly when the wither is light. The loss may also occur when rolling very kutcha leaf even at reasonable speeds. The effect is apparently due to the shearing action of the expressed juice, points of high pressure being set up in the leaf when the speed of rolling or amount of juice is excessive, even though the pressure cap is fully raised. Speeds in excess of 60 r. p.m. are to be avoided in the first roll.

A similar effect is found when sifting after the first roll is inefficient, and a large percentage of fine leaf is carried through into the second roll. Subsequent heavy rolling of this material strips the hairs from the bud and deposits them indiscriminately over the coarse leaf. Loss of tip in this manner may extend to the point at which the whole of the coarse leaf acquires a dull bloom,

originating in the scattering of light from the abraded hairs which cling to the surface of the coarse leaf.

Many Managers aim to remove 20% of fine leaf after the first roll, though this figure is susceptible to variation with fineness of plucking.

Abrasion of dry leaf. An interesting source of dull tip has been observed during the past season, *viz.*, the rough handling of partly dried leaf between the first and second stages of firing. When discharged from the first machine, the finer particles of leaf are almost completely dry, and the leaf hairs being brittle, are highly susceptible to damage. When the second stage of firing is conducted in a machine of the endless-chain type, the automatic spreader may cause trouble. These spreaders will fulfil their function satisfactorily if their speed is reduced to one revolution per tray. Ten revolutions per tray (*i.e.*, 20 sweeps of the spreader) is not infrequently found, and in consequence the leaf is tossed about violently. The danger of loss of tip is increased when leaf is loaded in large quantities. This factor applies equally to the "gaping" of orange grades, when it is frequently possible to observe a cloud of fluff rising from the spreader, denoting loss of tip. Incidentally, a slow running spreader deals more satisfactorily with partly fired coarse leaf, avoiding the tendency to form rolls.

Loss of tip during Sorting.

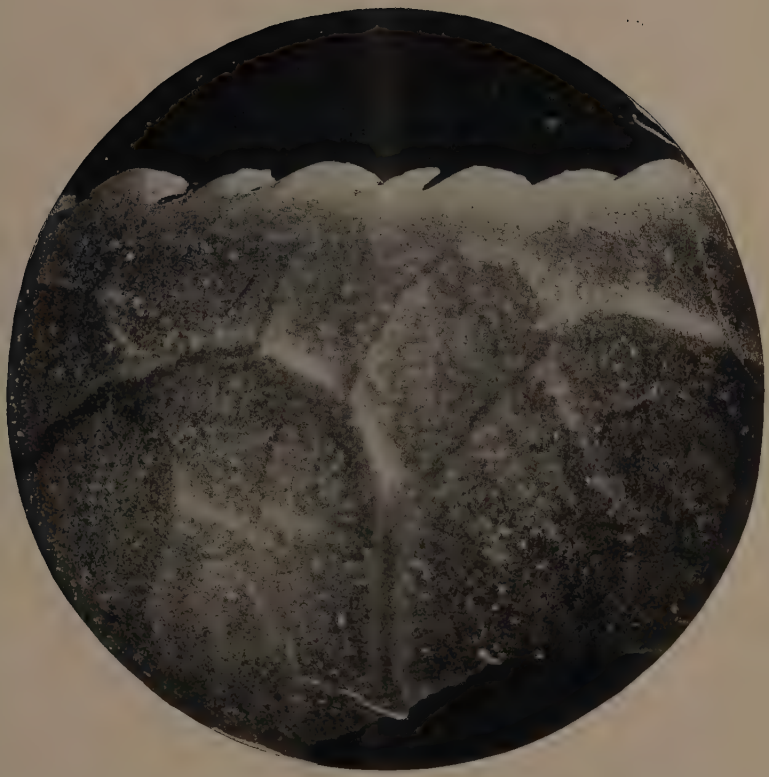
The factors concerned with the production of greyness during sorting (Quarterly Journal, 1931, Part III, pp. 141-142), apply with even greater force to the loss of tip. Any condition which allows the leaf particles to rub against each other or against a rough surface, even for a short time, is liable to cause abrasion of the hairs. The almost complete destruction of tip from O.P. and B.O.P. grades has been observed as the result of sorting the fine leaf in a machine of the Moore type where sagging trays of brass wire allowed the leaf to accumulate. Hand sorting on cane trays can lead to loss of tip if carried to excess.

When dealing with orange grades a straight run through the sorting machinery should be aimed at, and overloading should

be avoided. The same applies, should it be necessary to cut tippy teas. Tippy tea should not be sorted immediately after it leaves the firing machines and should be handled with great care at this stage. When firing has been carried to a full 12 annas in the first machine and to 16 annas in the second, the leaf hairs and the juice coating them are almost devoid of moisture, and in consequence are extremely brittle. After standing for some hours moisture will have been absorbed from the atmosphere, and the hairs will be less brittle.

Sorting room fluff.

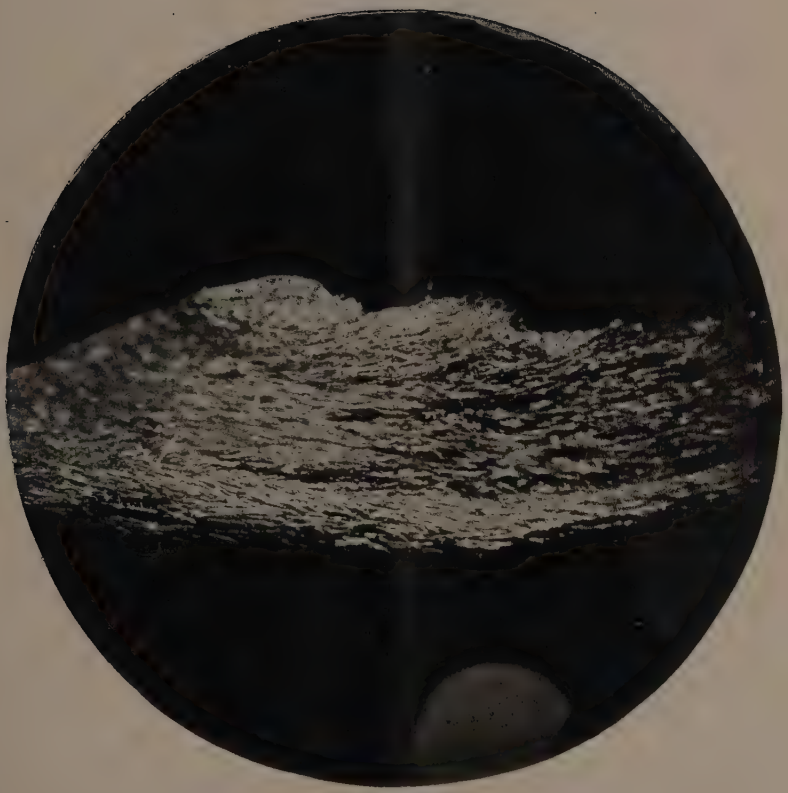
It is a significant fact that the microscopical examination of sorting room fluff has shown this to consist almost entirely of hairs which have been rubbed off the leaf. Factories which show the highest percentage of fluff are therefore suffering from the greatest loss of tip.



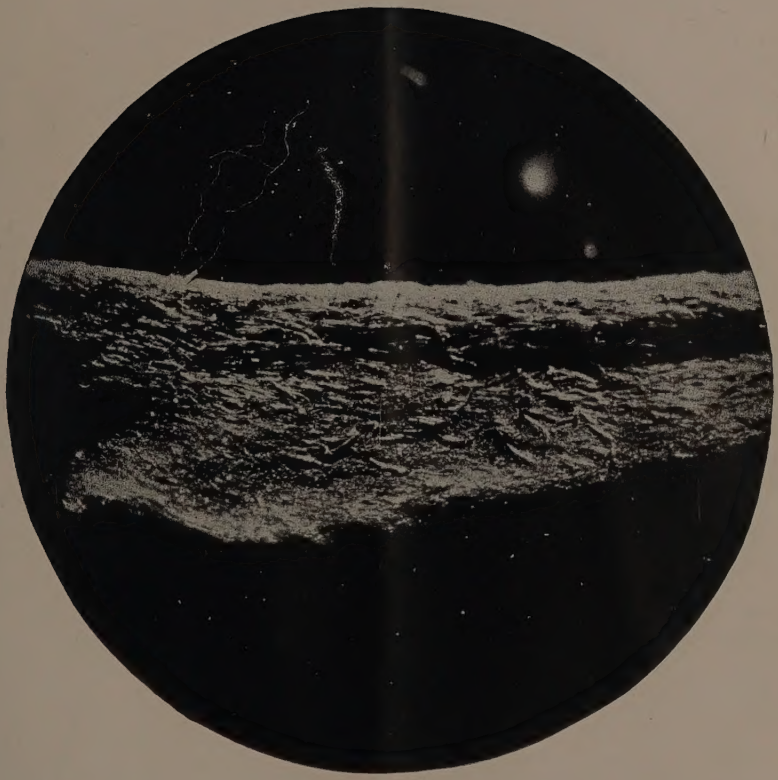
(1) *Opened bud without hairs.* A photomicrograph of the underside of a leaf recently unfolded from the bud, in which hair development is totally absent. Tip cannot be made from this type of bud.

(2) *Opened bud with hairs.* Hair development has taken place in these specimens, and should give rise to golden tip in manufacture.

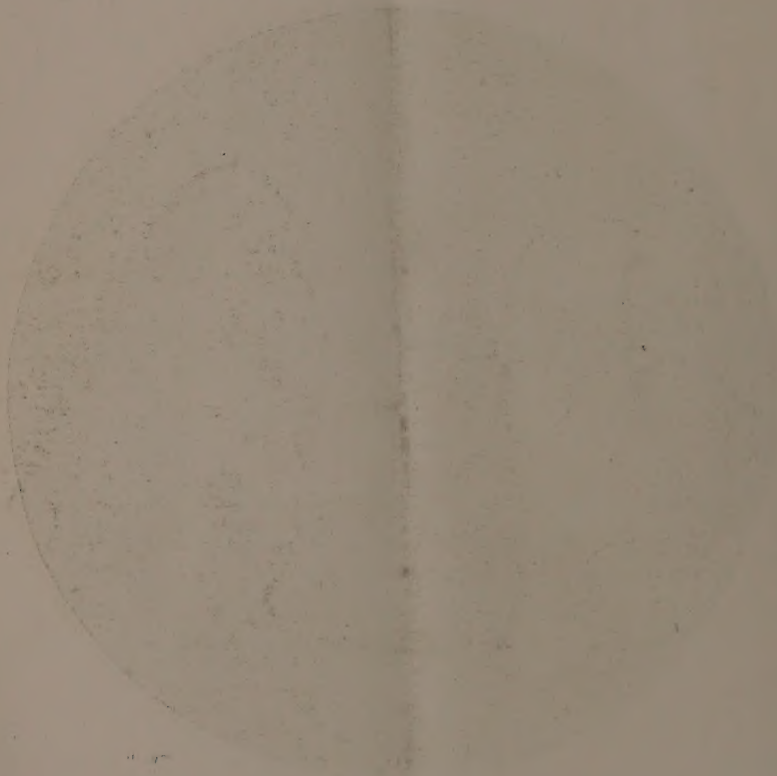
(3) Pronounced Hair Development on the bud.



(4) *Golden tip*. It will be observed that the whole surface of the leaf is covered by a mat of hairs.



(5) *Abraded tip.* Very few hairs are present, and the surface of the leaf is exposed. This appearance also arises when hair development on the bud is in defect.



(6) *Sorting room fluff.* The fluff is seen to consist almost entirely of hairs rubbed off the bud.